Price Level Targeting - The Role of Credibility

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1. Introduction

In the early literature on price level targeting, the main rationale for considering such a policy is to reduce price level uncertainty. If agents are better able to predict future prices this simplifies inter-temporal comparisons, encourages longer contracts, and avoids redistribution of income arising from incorrect price level expectations. The main cost of following such a policy is assumed to be the greater variability of output which is needed to restore prices to their target path.

More recently, price level targeting has been proposed as a desirable policy, even if the central bank does not have a specific preference about price level uncertainty, but rather wants to minimise the variability of inflation, output and interest rates. Incorporating a price level target into a monetary rule can reduce variability in these variables, compared to a purely inflation-targeting rule, if the price level target is completely credible.

To illustrate the effects a credible price level target has on expectations, consider an inflation-targeting central bank, faced with a positive shock which pushes inflation above target. The central bank needs to tighten policy to get inflation back to the target. Agents' expectations of future inflation are therefore likely to be above or at the target rate. Contrast this to the case of a price-level targeting central bank where the price level target grows over time at a constant rate of 2 per cent. This central bank, when faced with a positive shock that pushes inflation over 2 per cent, and thus the price level above the target path, must not only return inflation to 2 per cent, but must induce a secondary cycle with lower inflation, in order to restore the price level. If agents understand this policy, and believe the central bank is fully committed to the price level target, their expectations will be for inflation to dip below 2 per cent. In other words, inflation expectations will be lower with price level targeting than with inflation targeting. Thus more of the necessary adjustment in real interest rates can come about through changes in expectations rather than changes in nominal interest rates.

The assumption that price level targeting is fully credible, however, is a strong assumption to make. The aim of this project, therefore, is to explore how crucial this is to the results, and whether reductions in the variability of inflation, output and nominal interest rates are possible under different assumptions about how expectations are formed. The impact of adding price level targeting to a policy rule is considered with backward-looking expectations, model consistent expectations, and with credibility effects tied more specifically to inflation and price level targets. The sensitivity of results to different rules is also considered. More generally, the work provides an examination of whether results in the literature based on small analytical models can also be obtained in a larger model with far more complex dynamics - in this case the Bank of Canada's Quarterly Projection Model (QPM).

We find that it is possible to replicate key results from the literature using QPM, and that the assumptions made about expectations are very important in determining the final results. When agents are highly backward-looking, introducing a price level target into a Taylor rule results in increased output and interest rate variability. With highly model consistent expectations, however, it is possible to reduce the variability in inflation,

output and nominal interest rates. Incorporating credibility effects specifically tied to the price level target leads to even greater reductions in variabilities. But above all, it illustrates the dangers of exogenizing expectations: the results are driven by the assumptions and it makes little difference what monetary rule is used.

While some credibility is needed for price level targeting to generate reductions in the variabilities of inflation, output and nominal interest rates, the results suggest that complete credibility is not required. When expectations were based on the assumption of a mixed process where agents are partly backward-looking and partly forward-looking, adding a price level target can reduce variabilities if those agents who based their expectations on an inflation target switch to immediately basing expectations on the price level target. In other words some degree of credibility is essential, but it is considerably less than complete credibility.

Experimentation with different rules suggests that in QPM price level targeting gives more beneficial results (in terms of reducing key variabilities) if introduced into an explicitly forward-looking rule. Acting early to anticipate the future effects of shocks on the price level gives a smoother policy response and less cycling in interest rates and output.

Given that the effects on medium-term expectations are very important in determining the effects of price level targeting, results may be sensitive to assumptions made about the monetary transmission mechanism. In QPM, for example, while the monetary instrument is the short-term interest rate, the link to real activity is via the yield spread. The monetary authority, therefore, must primarily influence the short-term real rate in order to alter real output.[1] It is unlikely, however, that the introduction of a price level target will have a large impact on such near-term inflation expectations. A credible price level target will have a greater impact on longer-term expectations and thus longer-term real rates of interest. Thus the degree to which price level targeting will reduce the need for the monetary authority to alter nominal rates of interest will likely be sensitive to assumptions made about the role of long versus short-term rates of interest in the transmission mechanism.

Section 2 below provides a description of the methodology including a brief overview of QPM, a description of the different assumptions made about expectations and the rules to be considered. Section 3 presents the results based on a contemporaneous Taylor-type rule. Section 4 considers whether the results from the Taylor rule are robust for other types of monetary rule and Section 5 concludes.

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1. In QPM the real 90-date interest rate is defined as the nominal 90-day rate deflated by an average of expectations of this quarter's inflation in the consumer price index excluding food and energy, and in the GDP deflator.

2. Methodology

The principal means of evaluating price level targeting in this paper is to incorporate a price-level gap into different inflation-targeting rules within QPM, and to run stochastic simulations in order to compare the resulting variabilities of inflation, output and interest rates. Unlike many studies in this area, no loss function is specified. Rather, we are interested in seeing what trade-offs occur when price level targeting is introduced. If all three variabilities fall, this is assumed to be an unambiguously better result. Similarly, we are not considering the broader question of welfare gains from price level targeting. To do this properly would require specifying utility functions for consumers and to consider the costs of price level uncertainty. These are beyond the scope of this project. Our aim is limited to answering the following question: under what assumptions about expectations can price level targeting reduce the variabilities of inflation, output and nominal interest rates?

Since the analysis is based on QPM, an overview of the model is given below. This is followed by a review of the assumptions used regarding expectations and a brief description of the methodology for performing stochastic simulations.

2.1 The Quarterly Projection Model (QPM)

QPM is a system of two models: a well defined, neo-classical steady-state model (SSQPM), which determines the long-run equilibrium and a dynamic model which traces the adjustment path between the starting conditions and the steady-state. [2]

Within SSQPM, there are three key groups of agents: consumers, profit-maximising firms and government. Consumer behaviour is modelled on the Blanchard-Weil model of overlapping generations. Consumers have a desired level of wealth and make decisions on savings and consumption over time to reach that level. Firms determine the capital stock and associated rates of investment. The government sector determines the level of debt and associated levels of government expenditure and taxes. These decisions take place in the context of an open economy, where the exchange rate must adjust to ensure the current account balance is consistent with the flows needed to service any foreign debt.

Within the dynamic model (QPM), there are a number of important features which affect the path of the economy over the short and medium terms. Adjustment of both prices and quantities is assumed to be costly so there is an intrinsic element to the dynamics. Agents are forward-looking, and their expectations are modelled as a combination of a backward-looking/adaptive component and forward-looking model-consistent values. QPM also incorporates endogenous fiscal and monetary policy reaction functions. The fiscal policy rule determines government expenditures and taxation based on an

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2. For detailed documentation on QPM and SSQPM see Black, Laxton, Rose, and Tetlow (1994), Armstrong, Black, Laxton, and Rose (1995), and Coletti, Hunt, Rose and Tetlow (1996). For a less technical review of QPM and its use at the Bank of Canada see Poloz, Rose and Tetlow (1994).

exogenously determined target debt-to-GDP ratio. The objective of monetary policy is to control inflation. In the base model monetary policy is implemented through a forward-looking reaction function that adjusts the policy instrument to bring inflation into line with the inflation target. The instrument of monetary policy is the short-term interest rate, which affects domestic spending through the yield curve.

A key feature of QPM is that it is dynamically stable and the key stocks in the model (government bonds, capital and net foreign assets) are consistent with the economic theory in SSQPM. The necessary flows are supported by relative price movements, and if a shock affects a stock, the required flows are generated to return the model to its steady state.

QPM is not an estimated model: rather it is calibrated to reflect empirical evidence and established stylized facts. For example, the model is calibrated to ensure that there is a sacrifice ratio of 3:1 in a disinflation (i.e. in a 1 percentage point disinflation the cumulative output gap is 3 per cent), and a benefit ratio of 1 in an inflation shock. These properties are based on estimations of an asymmetric Phillips Curve for the period 1975 to 1991 by Laxton, Rose and Tetlow (1993).

2.2 Expectations

Price expectations in QPM are modelled in level terms as a function of three components: a backward-looking component, the model-consistent price level and the "perceived target". The perceived target can be thought of as a credibility effect, which captures agents' views about the inflation target being used by the monetary authority. (It is based on model-consistent inflation 4 to 5 years ahead.)

The expectation of the log level of the consumer price index excluding food and energy (CPI) in period t is:

$$LCPI_Et = BW*Backward+MC*Modelconsistent(t)+(1-BW-MC)*Perceivedtarget(t) \quad (1)$$

where BW is the weight on the backward component, MC is the weight on the model-consistent price level in period t, and the remainder of the weight goes on the perceived target i.e. the price level implied by the rate of inflation that agents believe the monetary authority is targeting. In other words, some people are backward-looking, some people have a very sophisticated view of the economy, and some people put weight on what they think is the inflation target being used by the monetary authority. While the weight on the credibility effect is exogenous, the value of the perceived target is endogenous and reflects how well the monetary authority is succeeding in keeping inflation near the target. If the monetary authority is following a policy which is successful at keeping inflation close to the target, the perceived target will be the same as the actual target. If the monetary authority is not following such a policy, however, the perceived target will drift away from the announced target.

Using this framework, the effects of inflation and price level targeting are considered under three alternative specifications of price expectations:

i) Highly backward-looking expectations, where 80 per cent of the weight within CPI expectations is on the backward component, 20% of the weight is on the model-consistent component and no weight is placed on the perceived target.

ii) Highly forward-looking expectations, where 90 per cent of the weight is on the model-consistent component of price expectations and 10% is on the backward-looking component. No weight is placed on the perceived target.

iii) Credible inflation target, where 80 per cent of the weight is on the perceived target. The backward-looking and model-consistent components each have a 10% weight.

In addition, a fourth specification of expectations is tried which incorporates price level credibility. The target price level is incorporated directly into expectations with a weight of 0.8:

$$LCPI_Et = 0.1*Backward + 0.1*Modelconsistent(t) + 0.8*Priceleveltarget(t) \quad (2)$$

2.3 Monetary Rules

Initially, price level targeting is added into a simple Taylor rule. As described above, the monetary instrument in QPM is the short-term nominal interest rate, which affects activity through the yield spread (the difference between the nominal 90-day rate and the nominal 10 year rate). The Taylor rule is written, therefore, in terms of the yield spread gap i.e. the difference between the slope of the nominal term structure and its risk-adjusted steady state value:

$$Yieldspreadgap(t) = \alpha*Outputgap(t) + \beta*Inflationgap(t) + \lambda*Pricelevelgap(t) \quad (3)$$

where Outputgap(t) is the contemporaneous output gap, Inflationgap(t) is the gap between year-over-year inflation of the CPI and the target rate of inflation and Pricelevelgap is the difference between the level of the CPI minus the target price level, normalised by the target price level i.e. (cpi(t)-cpitarget(t))/cpitarget(t).

The main version of QPM uses an inflation-forecast based (IFB) rule. Previous work at the Bank by Armour and Maclean has found that contemporaneous Taylor rules do not seem to perform as well as IFB rules in QPM, in that they are generally associated with higher variabilities of inflation, output and interest rates. This is in part because of greater secondary cycling. Nevertheless, Taylor rules are more robust to model changes than IFB rules. With an IFB rule, both the coefficient values and the optimal degree of forward-lookingness will likely change given changes in assumptions about expectations. In other words, when an IFB rule is used, the appropriate degree of forward-lookingness of both the inflation and price level gaps needs to be re-established for each different assumption about expectations. Given the time needed to perform such simulations, this raises severe practical difficulties.[3] For this reason, the analysis focuses initially on contemporaneous

Taylor rules. The robustness of these results across other rules is considered, however, in Section 4.

Within the Taylor rule, it is assumed that the central bank is targeting an inflation rate of 2 per cent. The target price level is also assumed to increase by 2 per cent a year. Thus, any difference in results is not as a result of a different implied target rate of inflation, but purely as a result of the weight on price level targeting. For the stochastic simulations, the coefficients on the inflation and price level gaps are varied (β and λ in Equation 3).The coefficient on the output gap is kept constant at 0.5.[4]

2.4 Stochastic Simulations

Stochastic simulations are based on shocks which are calibrated to be broadly representative of the historical distribution of shocks affecting the Canadian economy. (A brief review of the calibration technique is given in the Appendix.) For each set of Taylor rule coefficients, 100 replications are performed, each replication being a simulation of 109 quarters.[5]

When looking at the results of the stochastic simulations, three measures of variability are examined: the root mean squared deviation (RMSD) of inflation from target, the RMSD of the output gap from zero,[6] and the standard deviation of interest rates. It is important to note that the RMSD calculations have two components: the standard deviation, and the bias. The fact that QPM incorporates an asymmetric Phillips curve means that under an inflation targeting regime the mean of inflation is generally higher than 2 per cent in stochastic simulations i.e. there is a positive bias. (Given random shocks, if excess demand feeds into inflation more strongly than excess supply, on average inflation will tend to be above 2 per cent.) Under price level targeting, however, there is no such bias since inflation must average 2 per cent in order for price levels to return to their target path. Due to the asymmetric Phillips curve, the average output gap will be negative under both regimes.[7]

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3. For example, running 100 replications of 109 quarters each, for 15 different rules, requires 50 Sun Ultra workstations running simultaneously for 10 hours.

4. The coefficient is based on previous work at the Bank by Armour and Maclean where Taylor rules were evaluated within QPM and the most appropriate coefficients chosen.

5. The results from the first 8 quarters are ignored to ensure the summary statistics are not affected by the starting-point values.

6. This is equivalent to the square root of the sum of squares of the output gap.

7. The average output gap can increase or decrease when price level targeting is introduced, depending on the extent to which changes in expectations help the monetary authority in achieving its inflation and/or price level target.

3. Results for Taylor Rules

3.1 Backward-Looking/Adaptive Expectations

Price level targeting is introduced into a Taylor rule, when price expectations are assumed to be highly backward-looking, and the weights on both the inflation and price level gaps are varied. The results for inflation and output variability and inflation and nominal interest rate variability are shown in Figures 1 and 2 respectively. Within each figure, the lines show points where the weight on the inflation gap (β in Equation 3) is held constant. The line furthest to the right in Figure 1, for example, has a weight of 0 on the inflation gap. The highest weight used is 4. Moving down the points on a given line shows the impact of increasing the weight on the price level gap (λ), given a constant weight on the inflation gap. It is important to note that the lowest weight shown on the price level gap is not the same for all lines. For example, for weights of 2 and higher on the inflation gap, the first point shows a zero weight on the price level gap. Thus the difference between no price level targeting and a small weight on the price level target can be compared. With lower weights on the inflation target it was not possible to simulate the model with a zero weight on the price level target, therefore the first point on the lines already includes a positive λ coefficient.

The results suggest that if private agents are largely backward-looking, the introduction of an element of price level targeting at best leads to a trade-off between inflation variability and the variabilities of output and nominal interest rates. For very low weights on the inflation gap, there is a greater reduction in inflation variability when price level targeting is added. This largely reflects, however, the fact that they are poor rules to begin with. For coefficient values on the inflation gap which give more desirable results – 2 and 3 – there is very little reduction in inflation variability when a price level target is added. There are, however, increases in output and interest rate variability. For all the weights on the inflation gap, once the weight on the price level target increases beyond a certain point inflation, output and interest rate variability all increase.

The inset graph shows the frontiers for the rules with and without price level targeting. The lightly-shaded area shows the variabilities which can be achieved with those rules which include a price level target. The dark line shows the extra points which can be achieved with those rules which do not include price level targeting. Again, it is evident that lower output variability can be obtained with rules which do not include price level targeting.

There are two main reasons why price level targeting leads to increases in output and interest rate variability with largely backward-looking expectations: first, a secondary cycle must be induced to restore price levels which is unnecessary under an inflation targeting regime; second, there is continual overshooting of the price level target so that the cycling continues for much longer than just a secondary cycle. The first reason is the traditional cost cited in the early literature on price level targeting. The second may be more model or rule specific. The overshooting occurs because both the backward-looking expectations and other lags in the model mean that when the price level gap closes after

the monetary authority has, for example, been trying to increase inflation, there are still inflationary pressures that continue to push inflation above the 2 per cent target for a number of quarters. The monetary authority therefore misses its target, and must then induce a cycle of below-target inflation. Part of the problem may be, therefore, that a rule based on contemporaneous data is not adequately forward-looking. For this reason, more forward-looking versions of the rule are considered in Section 4 below.

3.2 Model Consistent Expectations

The second major assumption made for expectations is that they are based largely on model consistent values of future inflation. This assumes, therefore, that agents have a full understanding of the shocks hitting the economy, a full understanding of the model of the economy and that they know the rule being followed by the monetary authority. This assumption is used in many of the key papers which have found a role for price level targeting such as Svensson (1997), Vestin (2000) and Dittmar, Gavin, and Kydland (1999). The results of simulating the same rules as previously are shown in terms of inflation and output variability (Figure 3), inflation and nominal interest rate variability (Figure 4) and inflation and real interest rate variability (Figure 5).

In a world of highly model consistent expectations, introducing a small weight on the price level target can unambiguously improve model properties, with the variabilities of inflation and output declining and nominal interest rate variability remaining largely unchanged. This can be seen, for example, in Figure 3 where the weight on the inflation gap is held constant at 2, and a small weight of 0.5 is introduced on the price level gap. (Remember that for weights on the inflation gap of 0 and 0.5, it was not possible to simulate a zero weight on the price level target, thus we cannot see the impact of moving from no price level targeting to a small weight on the target.) Inflation and output variability both fall. Introducing the price level gap causes no significant change in nominal interest rate variability (Figure 4), but real interest rate variability increases. This is consistent, therefore, with the idea that price level targeting affects expectations in a manner which is beneficial to the monetary authority i.e. above-target inflation will be expected to be followed by below-target inflation. There is less need for the monetary authority to adjust nominal interest rates, therefore, in order to generate the required real interest rate variability.[8] The result of unchanged nominal interest rate variability is not robust across all weights, however. For example, if the weight on the inflation gap is 3, nominal interest rate variability clearly increases with the addition of a price level target.

It is interesting to note that further increases in the weight on the price level target create the same trade-offs as in the backward-looking example, where inflation variability falls initially but output and interest rate variability increase. This is because the key benefits

8. Looking at the results of individual replications shows that the gains occur most in those simulations where the draws of shocks lead, with an inflation-targeting rule, to sustained periods of inflation outside the inflation target bands of 1 to 3 per cent. In these situations, adding a small weight on the price level target has a significant impact on expectations and helps bring inflation back within the bands much more quickly. Moreover, it does so with less need for nominal interest rate variability.

come from the changes in expectations, and the main benefits from these accrue even with only a small weight on the target. Similarly, even with model consistent expectations, the rules which have no weight on the inflation gap and only weights on the output and price level gaps (the line marked $\beta=0$) are associated with generally higher variabilities of inflation, output and interest rates than those which have a weight on the inflation gap. Thus, while these results do suggest a role for some weight on a price level target, they do not support a pure price level targeting rule.

The inset graph in Figure 3 again provides a good summary of the effect of price level targeting on output and inflation variability when expectations are highly model consistent. The frontier of the darkly-shaded region shows the best points achievable with no weight on the price level target. The lightly-shaded region shows the extra points which are attainable with the inclusion of a price level target. Clearly, both inflation and output variability can be reduced.

3.3 A Highly Credible Price Level Target

Making expectations model consistent introduces a form of credibility, since agents implicitly know the rule being followed by the monetary authority. A much stronger assumption about price level credibility can be made, however, by putting the price level target directly into expectations. This assumes less sophisticated agents than the model consistent agents, who do not necessarily understand the model of the economy or the nature of the shocks, but believe the monetary authority is fully committed to maintaining the target, and thus base their expectations on this target path.

Incorporating the price level target path directly into expectations with a high and completely exogenous weight is, of course, a very strong assumption to make. This becomes very obvious when looking at the results from varying the monetary rule under such an assumption. These are shown in terms of inflation and output variability in Figure 6. Also shown in this graph for comparison are the results from the same rules when agents were assumed to be backward-looking (i.e. the results from Figure 1).

Compared to the case with backward-looking expectations, a highly credible price level target is clearly associated with much lower variabilities of inflation and output. Varying the weights within the rule, however, makes little difference. The results are being completely driven by the assumptions made about expectations. In other words, if expectations are determined by an exogenous assumption, it makes little difference what rule is used. The outcomes will be very similar regardless. Clearly, this is not a desirable assumption to make. Incorporating endogenous credibility, where the "credibility coefficient" perhaps responds to deviations of the price level from target, would be an interesting path for future research.

3.4 A Highly Credible Perceived Inflation Target

One final form of credibility is considered - a highly credible inflation target. It may seem a little odd to incorporate a credible inflation target when it is price level targeting that is

being considered. But conceivably, if a monetary authority has been following a successful inflation targeting regime, agents may place a high weight on the target in their expectations. If they do not completely understand the shift to a new regime of price level targeting, they may continue to place weight on what they think of as the inflation target. This combination, therefore, could capture the transition period from one regime to another. As described above, the credibility effect for an inflation target in QPM is incorporated by including a term capturing agents perceptions of the target being used by the monetary authority. This "perceived target" is endogenous, and will diverge from the actual target if the monetary authority is not keeping inflation close to the target.

The results are shown in Figures 7 and 8, again compared to the results with backward-looking expectations (i.e. the results from Figure 1). Placing a small weight on the price level target at best decreases the variability of inflation, but increases the variabilities of output and interest rates. This is not surprising, since the benefits of price level targeting that are derived from changes in expectations do not occur if agents are still basing expectations on a perceived inflation target. The changes in all variabilities are extremely small, however. Again, exogenizing expectations in this manner is clearly a strong assumption.

3.5 Expectations Based on a Mixed Process

The above results support the general idea that price level targeting can improve inflation, output and nominal interest rate variability if agents incorporate targeting behaviour into their expectations. These results are based, however, on extreme assumptions about expectations - price level targeting appears to have a role if it is highly credible, or if agents are almost all forward-looking and understand the policy being followed and how the economy works. This raises the question of what would happen if we made some less extreme assumptions, where expectations are based on a mixed process incorporating elements of backward-looking and model consistent expectations.

To answer this question, the same rules were simulated, but this time with two sets of expectations, very similar to those used in the base case of QPM i.e. the version which is used for doing projections at the Bank of Canada. In base-case QPM, expectations have a weight of around 0.7 on the backward component, a weight of around 0.2 on the model consistent component, and a weight of around 0.1 on the perceived target. The rules were simulated based on this formulation of expectations. In addition, it was assumed that the 10 per cent weighting on the inflation target in the base case formulation switches to a weight on the price level target. Figures 9, 10 and 11 show the results of both sets of simulations for inflation and output variability, inflation and nominal interest rate variability and inflation and real interest rate variability respectively. In each graph, the dot-dashed line shows the results using base-case expectations (i.e. including a 10 per cent weight on the perceived inflation target) and the solid lines show the results using the same weights on components for expectations, but this time with a credibility effect based on the price level target.

The results from the base-case expectations show that, in such an environment, adding a weight on the price level target in the policy rule causes the same trade-off seen in the backward-looking examples: inflation variability may fall, but it is at the cost of increased output and nominal interest rate variability. Clearly, the smaller weight on the model consistent element is not enough to generate unambiguously beneficial effects. If, however, the 10 per cent of people who base their expectations on the inflation target switch to basing their expectations on the price level target, this is enough to generate declines in inflation and output variability. This can be seen in the shift between the dot-dashed and solid lines. Point A, for example, shows a point with no weight on the price level target, a weight of 2 on the inflation target, and base case expectations. Adding a weight on the price level target in the policy rule with no changes in assumptions about expectations, represents a movement along the line to point B. Adding a weight on the price level target in the policy rule and assuming the credibility effect switches to the price level, represents a movement to point C. At this point, the variabilities of output and inflation have fallen compared to A, and nominal interest rate variability is almost unchanged.

Another way of looking at this information is to consider the frontiers for price level and non-price level targeting rules. These are shown in the inset graph in Figure 9. The frontier of the darkly-shaded region shows the best points achievable with only an inflation target, when around 10% of people base their inflation expectations on the perceived target. The lightly-shaded region shows the extra area attainable with price level targeting, if credibility switches from the perceived inflation target to the price level targets.[9] This area includes rules associated with both lower inflation and output variability.

Thus, the introduction of price level targeting can induce a lower variability of output with little increase in interest rate variability, under considerably less restrictive assumptions than complete credibility or completely model consistent expectations. Moreover, it is worth stressing that the assumptions made about expectations and credibility of the inflation target in base case QPM are not purely arbitrary. They are carefully calibrated to try and reflect empirical evidence on the behaviour of expectations and the costs of disinflation. A number of studies suggest that credibility has increased in the last few years, and in light of these results, the weight given to credibility within QPM can be viewed as a relatively cautious one.[10] It is not completely clear, however, whether credibility is linked to the Bank of Canada or more specifically to the inflation targets. If it is the former, then the assumption that those directly incorporating the perceived target into their expectations switch to using the price level target path is not unreasonable. If it is the latter, however, with credibility linked to the inflation target, price level targets

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9. Note that the frontier of the lightly-shaded region is notional in that it shows points where some people place weight on a price level target, but the policy rule has a zero weight on the price level gap. All points to the right of the frontier, however, are associated with both some price level credibility and a non-zero weight on the price level gap in the policy rule.

10. For a good review of recent studies on the credibility of monetary policy in Canada, see Perrier and Amano (2000).

would not necessarily have the same degree of credibility, particularly when newly-introduced. The above results suggest that in this case, introducing price level targets would lead to higher output and interest rate variability.[11]

4. Sensitivity of Results to the Taylor Rule

For largely practical reasons, the analysis of price level targeting described above was done using contemporaneous Taylor-type rules. Past work, however, has found that such rules do not give as desirable model properties in QPM as explicitly forward-looking IFB rules. They are generally associated with higher variabilities of output and interest rates, in part due to considerable secondary cycling. There is a concern, therefore, that the results may be sensitive to the fact that the starting-point rule is not a good rule to begin with. For this reason, we reconsider some of the key results using IFB rules. The above analysis also keeps the weight on the output gap unchanged. Conceivably, however, a price level targeting rule may perform better with different weights on the output gap. The sensitivity of results to changes in the output gap coefficient is, therefore, also considered below. Finally, within the Taylor rule framework, adding a small weight on a price level gap is sometimes beneficial, but the results do not support completely replacing the inflation gap with a price level gap. This may be, however, because a Taylor rule framework is not the most appropriate one for price level targeting. Consideration is given, therefore, to formulating a rule which is more explicitly oriented to a purely price level targeting regime.

4.1 Inflation Forecast Based (IFB) Rules

To check the robustness of the results obtained using the Taylor rules, price level targeting is introduced into IFB rules under the assumptions of largely backward-looking expectations and highly model consistent expectations. The IFB rule used is again in terms of the yield spread, with weights on a forward-looking inflation gap (where the degree of forward-lookingness is t+i) and a forward-looking price level gap (where the degree of forward-lookingness is t+j):[12]

$$\text{Yieldspreadgap}(t) = \beta * \text{Inflationgap}(t+i) + \lambda * \text{Pricelevelgap}(t+j) \qquad (4)$$

As well as varying the weight on the coefficient values, the appropriate degree of forward-lookingness for both the inflation and price level gaps has to be found for the two different assumptions about expectations. These were chosen by first selecting the degree

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11. The result that some adjustment in expectations must occur for price level targeting to lower variabilities is also consistent with that found in Black, Macklem and Rose (1997). This is encouraging as regards the robustness of the result since while they were using a similar model to QPM (the Canadian Policy Analysis Model), they incorporated credibility in a very different manner, and were using very different shocks in the stochastic simulations.

12. Note, that unlike the base-case IFB rule in QPM, no weight was placed on either the output gap, or the lagged yield spread gap.

of forward-lookingness for the inflation gap, assuming a zero weight on the price level target. The selection was made on the basis of trying to minimise inflation, output and interest rate variabilities. Once this was selected, a range of positive coefficient values on the inflation and price level gaps are considered, with different degrees of forward-lookingness on the price level gap.

In the case of highly backward-looking expectations, the appropriate degree of forward-lookingness for the inflation gap is 6 to 7 quarters ahead (which is the time horizon used in the base case QPM rule). When searching for the appropriate lead on the price level gap, a greater degree of forward-lookingness always appears better. (We tried up to 8 to 9 quarters ahead.) This can be seen in Figures 12 and 13 which show the results of varying the weight on the inflation and price level gaps, given different degrees of forward-lookingness of the price level gap. The solid lines show 4 to 5 periods ahead, the dotted 5 to 6, the dot-dash line 6 to 7 and the dashed line 7 to 8 periods ahead. A greater degree of forward-lookingness is generally associated with lower inflation and interest rate variability. Varying the weights on the inflation and price level gaps makes a bigger difference to the variabilities, however, than varying the degree of forward-lookingness. Moreover, for all degrees of forward-lookingness, the previous result that adding a price level target is associated with a trade-off between lower inflation variability but higher output and interest rate variability is unchanged.

Under the second assumption of highly model-consistent expectations, the most appropriate lead on the inflation gap was found to be 5 to 6 quarters ahead.[13] Figures 14, 15 and 16 show the results for different leads on the price level gap. Again, a more forward-looking price level gap gives lower output and inflation variability but higher interest rate variability.

For all degrees of forward-lookingness, the general results obtained with the Taylor rule appear robust, but the gains from adding a small weight on a price level target are considerably greater. Not only do inflation and output variability decline, there are also significant declines in nominal interest rate variability. The gains are also evident for a greater range of weights on the inflation gap term. In some cases, additional gains also occur not just with the initial introduction of the price level target, but when the weight increases from 0.5 to 1.

The fact that price level targeting does better in an IFB rule is broadly consistent with previous work in QPM comparing IFB and Taylor rules. In QPM, in the context of an inflation-targeting rule, it is always better to anticipate the effects of shocks ahead of time. When the monetary authority acts early, the policy response can be much smoother. Acting later requires a sharper initial response, and is associated with greater secondary cycling of interest rates and output. In the context of price level targeting, looking ahead and anticipating the effects of shocks to allow a smoother response is even more

13. This is consistent with Amano, Coletti and Macklem (1999) who found that the optimal lead on the inflation gap in an IFB rule declines when credibility is increased.

important. This can be seen in the above results, where the most appropriate horizon for the price level gap is found to be more forward-looking than that of the inflation gap.

A question remains about how specific the results for the effects of price level targeting in the Taylor and IFB rules are to QPM. In particular one feature of QPM which may be important is that monetary policy affects activity through the yield spread. In order to affect real activity, therefore, the monetary authority must influence real short term interest rates.[14] The real short-term rate is defined as the nominal rate deflated by expectations of current inflation. Even if agents believe that the monetary authority is committed to returning to a price level target, they will hardly expect the effects of a shock to be reversed in the next quarter. Thus changes in the short-term real rate will not be large. Price level targeting may, therefore, do better in models where the transmission mechanism depends on longer-term rates of interest. Changes in medium-term expectations stemming from the price level target would then have a greater impact on those rates which affect real activity.

This has interesting implications for the likely effect of price level targeting in the presence of binding zero nominal interest rate floors. Many authors have proposed price level targeting as a means of avoiding problems associated with a zero nominal interest rate floor in a low inflation economy.[15] During a period of disinflation, nominal interest rates can not fall below zero, but if agents expect a period of higher inflation in the future to restore the price level target path, real interest rates can still adjust through changes in expectations. The above results suggest, however, that in a model such as QPM where short-term real rates are important in the monetary transmission mechanism, incorporating price level targeting may not greatly reduce problems with zero nominal interest rate floors, because the main changes to expectations occur in the medium term and thus do not directly affect the short-term real rate.

4.2 Varying the Weight on the Output Gap

In the above simulations where the price level is added to a Taylor rule, the weight on the output gap is kept constant at 0.5. To check whether varying the weight on the output gap could lead to better results with price level targeting, the rules were simulated with weights of 1, 2 and 3 on the output gap under the assumption of highly model consistent expectations. These results are shown in Figures 17 and 18. (Although not specifically marked, the coefficient values for the inflation gap are the same as those used in the previous simulations.) In Figure 17 it can be seen that increasing the weight on the output gap generally decreases output and inflation variability, but makes no real difference to the comparison of rules with and without price level targeting.[16] Similarly, increasing the weight on the output gap leads to generally higher nominal interest variability, but as

14. This contrasts, for example, with models of the U.S. where activity is generally tied to longer-term rates of interest.

15. Papers dealing with this issue include Wolman (1998), Woodford (1999) and Reifschneider and Williams (1999).

before, adding a small weight on the price level target is generally associated with little change in nominal interest rate variability.

4.3 A Contemporaneous Price Level Targeting Rule

Much of the above work involves adding a price level target into a Taylor rule. Remember that a Taylor rule has an inflation gap term (since the monetary authority is assumed to be targeting inflation) and an output gap term which largely plays the role of providing forward-looking information about future inflation. Incorporating a price level target into this framework is in some ways a little strange. After a positive shock to inflation, for example, the inflation and price level gap terms will both be positive initially. But at some point, in order to restore the price level target, inflation must fall below "target" while the price level gap is still positive. Thus the two components will have opposite signs. An alternative idea is to try to develop a specifically price level targeting rule, in the same spirit as the Taylor rule i.e. which includes the price level gap and a term which provides information about the future price level.

Three different rules were tried: a rule consisting of the price level gap and a cumulative output gap; a rule consisting of the price level gap, the output gap and the change in the output gap; and a rule consisting of the price level gap, the output gap and a moving average of past output gaps.[17]

$$\text{Yieldspreadgap}(t) = \alpha * \text{CumulativeOutputgap}(t) + \lambda * \text{Pricelevelgap}(t)$$

$$\text{Yieldspreadgap}(t) = \alpha * \text{Outputgap}(t) + \beta * \text{Changeinoutputgap}(t) + \lambda * \text{Pricelevelgap}(t)$$

$$\text{Yieldspreadgap}(t) = \alpha * \text{Outputgap}(t) + \beta * \text{MAoutputgap}(t\text{-}1 \text{ to } j) + \lambda * \text{Pricelevelgap}(t)$$

The first formulation, with the cumulative output gap, was in many ways the most intuitive of the three sets of rules. It did not produce good results, however, in that it was associated with generally higher variabilities of inflation, output and interest rates and in many cases the models never settled to their steady-state in deterministic simulations. The failure of the rules to incorporate exchange rate pass-through effects may be one reason for their poor performance. The performance of these rules was also very sensitive to the exact measure used for the cumulative output gap.[18] The rules which included the moving average of lagged output gaps were also associated with significantly higher

16. While weights on the output gap greater than 0.5 reduce output variability in stochastic simulations, they result in some undesirable model properties in deterministic shocks. The policy response to a negative demand shock, for example, is so extreme that the shock appears to be inflationary.

17. Averages of the past 2 and 5 years were tried.

18. The measures tried for the cumulative output gap were: the total cumulative output gap dating from the beginning of the simulation, the addition of output gaps over the past 5 years, and the addition of output gaps over the past 2 years. The non-linearity of the Phillips curve was taken into account when calculating the cumulative output gap measures.

variabilities of inflation, output and interest rates compared to the traditional Taylor rules with price level targeting.

The rules which performed the best were those which included the output gap and the change in the output gap. Including the change in the output gap increases the initial response to a demand shock (and decreases the initial response to a price level shock) but then causes a faster turn-around in interest rates once the trough or peak in output is passed.

The results of the change rules are shown in Figures 19 and 20, compared to the results from the traditional Taylor rules with price level targeting (the light grey dashed lines). As before, moving down the lines shows the effect of increasing the weight on the price level gap. The different sets of lines show different weights on the output gap, and each line within the set shows a different weight on the change in output. Initially, increasing the weight on the price level gap reduces both inflation and output variability. Beyond some point, however, further increases in the weight lead to a deterioration in these variabilities. Interestingly, the best coefficient values for the price level gap (around 3) are similar to the best coefficient values for the inflation gap term in the traditional Taylor rules. Increasing the weight on the change in output shifts the lines to the left i.e. leads to a reduction in output variability. This is at the expense, however, of slightly increased inflation variability.

There is a range of weights over which the new rules give very similar results to the Taylor rules with price level targeting, in terms of the variabilities of inflation and interest rates.[19] For example, with a weight on the output gap of 0.5, change rules with a weight of around 3 on the price level gap and 3 and 4 on the change, give similar variabilities to Taylor rules with a weight on 0.5 on the price level gap and 2 or 3 on the inflation gap. These rules are associated, however, with higher nominal interest rate variability. As can be seen in Figure 20, as the weight on the change in the output gap is increased, interest rate variability also increases. These results are consistent, therefore, with those in Section 3, which suggest that in terms of inflation, output and nominal interest rate variabilities, pure price level targeting rules do not give as desirable results as those rules which still contain a price level target.

5. Conclusion

We find that the assumptions made about expectations are crucial in determining the results from adding price level targeting into a Taylor rule. If agents are highly backward-looking, there are no clear gains from adding a price level gap. Rather, there is a trade-off between slightly decreased inflation variability on the one hand, and significantly

19. Note that while the overall variabilities for the two different models appear similar for some points, the model properties are quite different. The rules which include the change in the output gap and no inflation gap are characterised by a more aggressive initial reaction to demand shocks followed by a faster reversal of interest rates, and a less aggressive but longer reaction in price level shocks.

increased output and interest rate variability on the other. If agents' expectations are highly model consistent, however, the introduction of a small weight on a price level gap can reduce inflation and output variability, without significantly changing the variability of nominal interest rates. In addition, we find that gains from adding a price level target can occur with considerably less than fully model consistent expectations. In particular, using the version of expectations calibrated to reflect Canadian data, price level targeting improves the variabilities of inflation and output if the price level targets have the same credibility as currently placed on the inflation target. Nevertheless, some degree of credibility is required to generate lower variabilities.

Introducing an exogenous credibility effect, while giving desirable results in terms of the impact of price level targeting, is found to be a dangerous modelling strategy. It is too strong an assumption, which can give desirable results in terms of variabilities, even when relatively poor rules are being followed by the monetary authority.

While gains are found from adding in a small weight on a price level gap, the results do not support completely replacing an inflation target with a price level target. A number of different specifications of a contemporaneous price level targeting rule were tried, but none could outperform adding a small weight on a price level gap within a traditional Taylor rule.

When introduced into an explicitly forward-looking IFB rule, the gains from price level targeting are more significant. Even in an inflation-targeting regime in QPM, the policy response is much smoother when the monetary authority is forward-looking and anticipates the future effect of shocks. With price level targeting, being forward-looking appears even more important, so as to avoid unnecessary cycling in interest rates and output.

An important caveat to these results is that currently we are unsure how specific they may be to QPM. In particular, they may be sensitive to assumptions about the monetary transmission mechanism, and in particular the role of short versus longer-term interest rates. The potential benefits from price level targeting rely on the effect that changes in medium-term expectations have on the real interest rate, which in turn affects real activity. Medium-term expectations can, therefore, have a more direct impact if the monetary transmission mechanism relies on a longer-term rate of interest. This may limit the extent to which our results, for example, can be applied to U.S. models where activity is linked to longer-term rates.

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Appendix

The shocks used in the stochastic simulations are calibrated using an estimation-by-simulation approach. We start with a simple AR(1) representation of innovations, then re-parameterize them until QPM produces standard deviations and autocorrelation coefficients which match approximately those in the data. In other words, we are trying to match both the mix of shocks and their persistence. In particular, we try to match the variability and autocorrelation of the change in real output, inflation and the change in interest rates to those values calculated for the period from the first quarter of 1973 to the first quarter of 1998.[20] Shocks are introduced on 8 behavioral variables[21] and one exogenous variable (the level of steady state productivity). Shocks are also introduced for 4 variables capturing activity in the rest of the world. These are generated using an estimated VAR. For more details on the estimation-by-simulation approach, and the VAR used to generate the rest-of-world shocks, see Amano, Coletti and Murchison (1999).

Table A-1 shows the variability and autocorrelation measures from the base case calibration and over history for output, inflation and interest rates. It can be seen that the variability of output is higher than historically, whereas the variability of inflation is a little below the historical measure. This reflects the fact that QPM now has a more aggressive rule than that followed over the historical period.

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20. The choice of sample period is open to the criticism that variabilities may have altered over time, for example that output variability has fallen. This calibration is viewed as preliminary. Sensitivity analysis performed to check the robustness of results suggests however, that the main qualitative conclusions regarding changes in variabilities as rules differ are robust to reasonable variations in the variabilities of output and inflation.

21. Shocks are included for the GDP deflator, the CPI, real consumption, real investment, real exports, real imports, the total direct tax rate and wages.

Table A-1: Standard Deviations and Autocorrelation Coefficients With Their Corresponding 95 Per Cent Confidence Intervals for Selected Variables. QPM Sample Moments (in Bold).

Variables[a]	Standard Deviation	AR(1) Coefficient
Output		
Quarterly	3.0 < 3.4 < 3.9 < **4.8**	0.24 < **0.36** < 0.43 < 0.63
Annual	2.1 < 2.4 < 2.6 < **3.0**	0.67 < **0.82** < 0.87 < 1.06
CPI Less Food and Energy		
Quarterly	**1.9** < 3.1 < 3.5 < 4.1	0.61 < **0.56** < 0.80 < 1.00
Annual	**1.5** < 2.8 < 3.2 < 3.7	0.76 < **0.89** < 0.96 < 1.16
Yield Spread	1.2 < 1.4 < **1.5** < 1.6	0.54 < 0.74 < **0.85** < 0.93
10-Year Interest Rate	1.9 < **2.2** < 2.5	0.73 < **0.91** < 0.93 < 1.12
90-Day Interest Rate	3.0 < 3.4 < 4.0 < **4.9**	0.72 < **0.88** < 1.11

a. Quarterly indicates quarterly growth at annual rates. Annual indicates year-over-year growth.

Fig 1:Backward Expectations

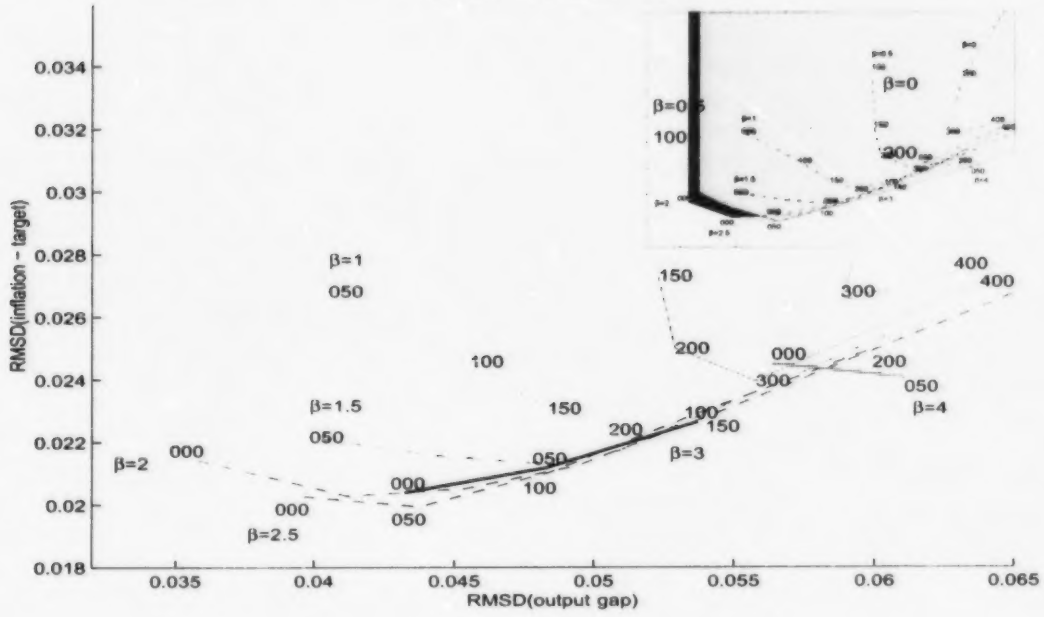

Fig 2:Backward Expectations

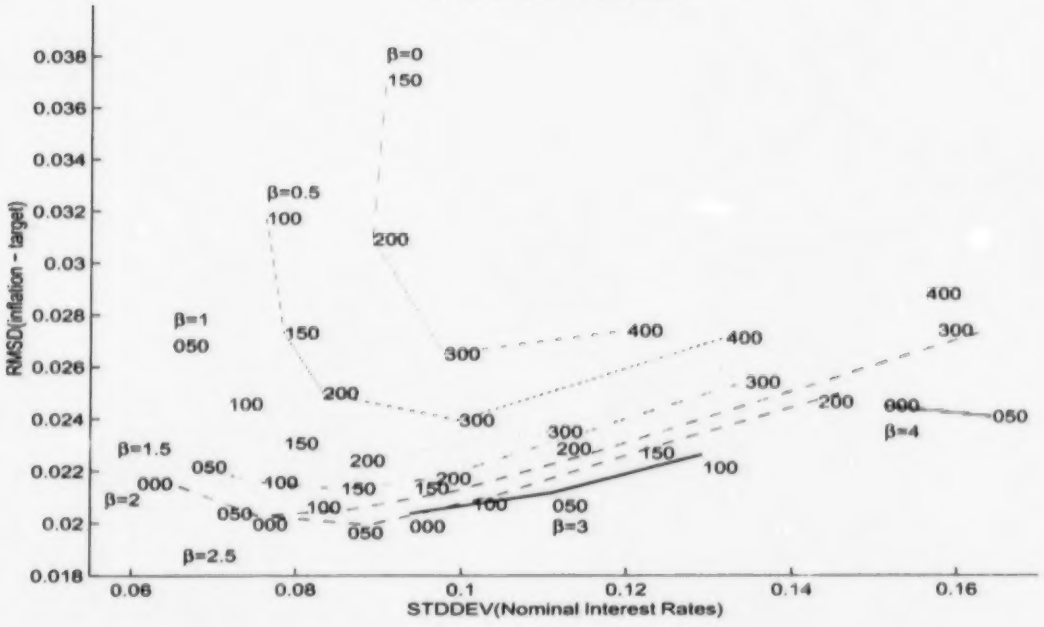

Fig 3 Model Consistent Expectations

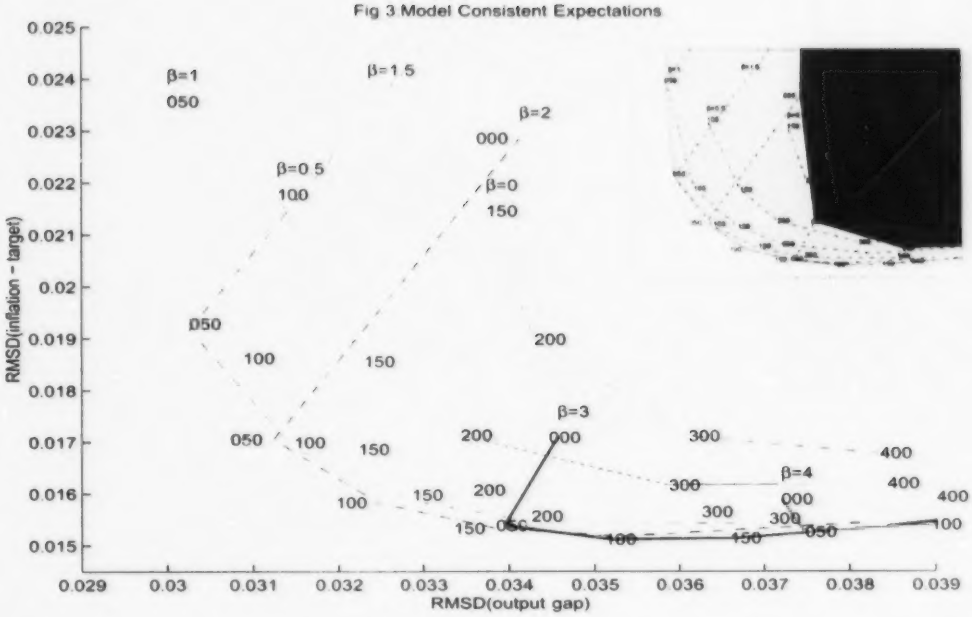

Fig 4 Model Consistent Expectations

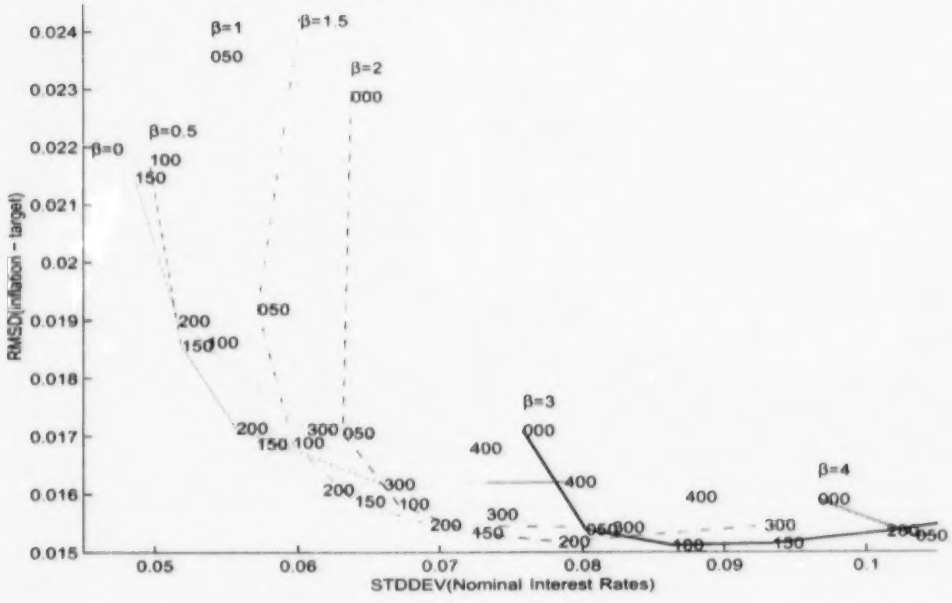

Fig 5:Model Consistent Expectations

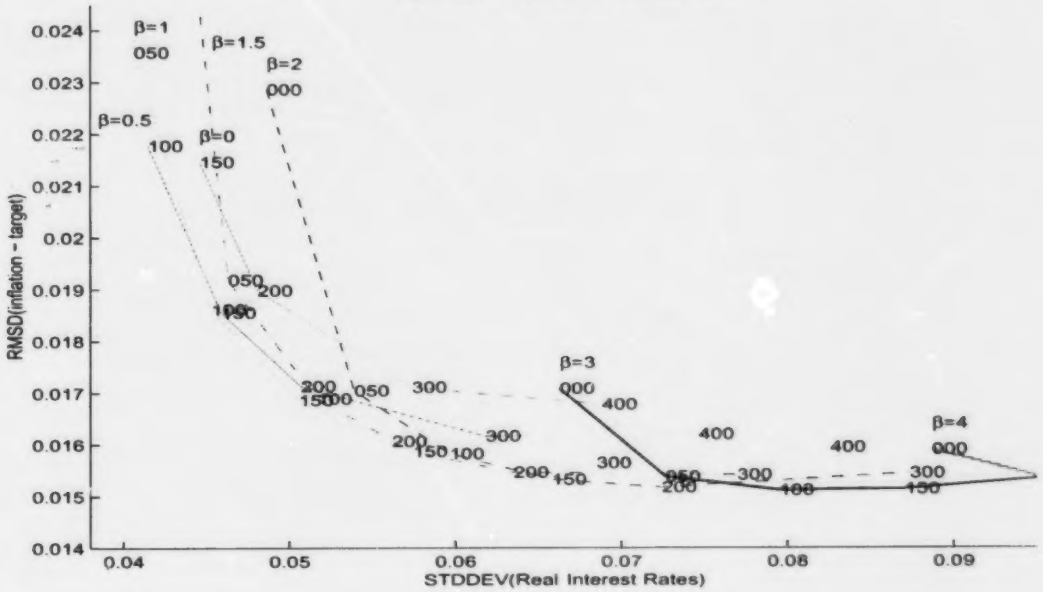

Fig 6:Highly credible price level target

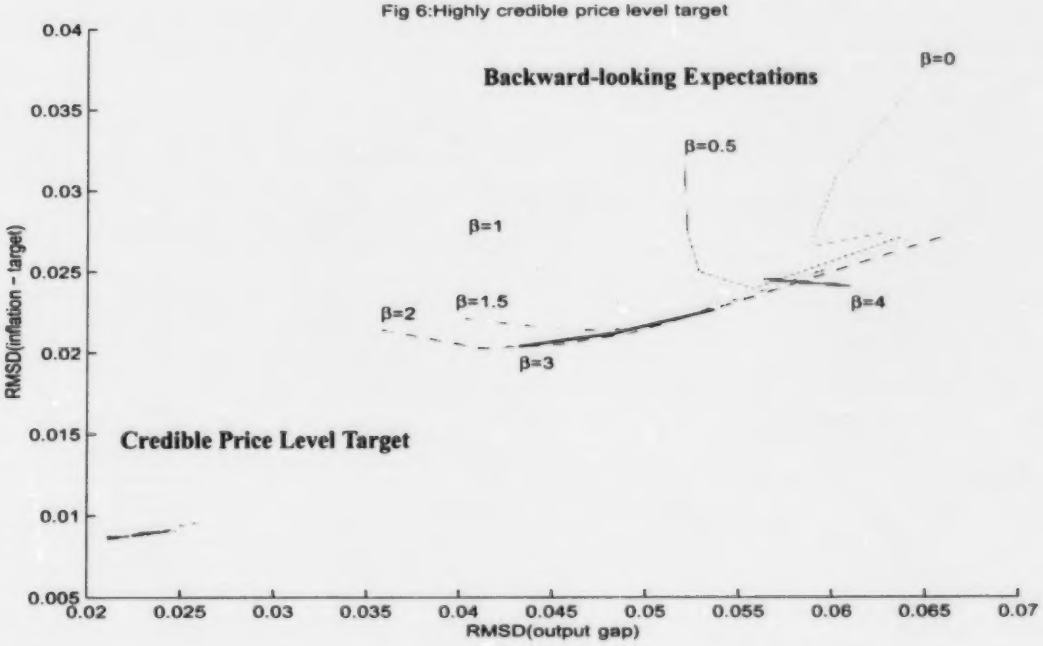

Fig 7:High Credibility of Inflation Target

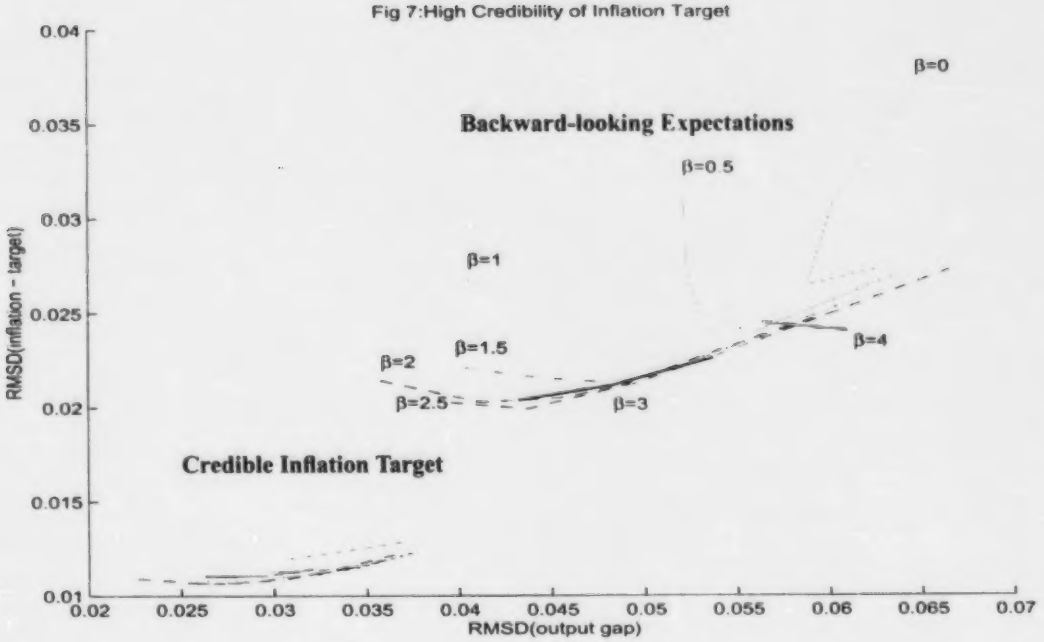

Fig 8:High Credibility of Inflation Target

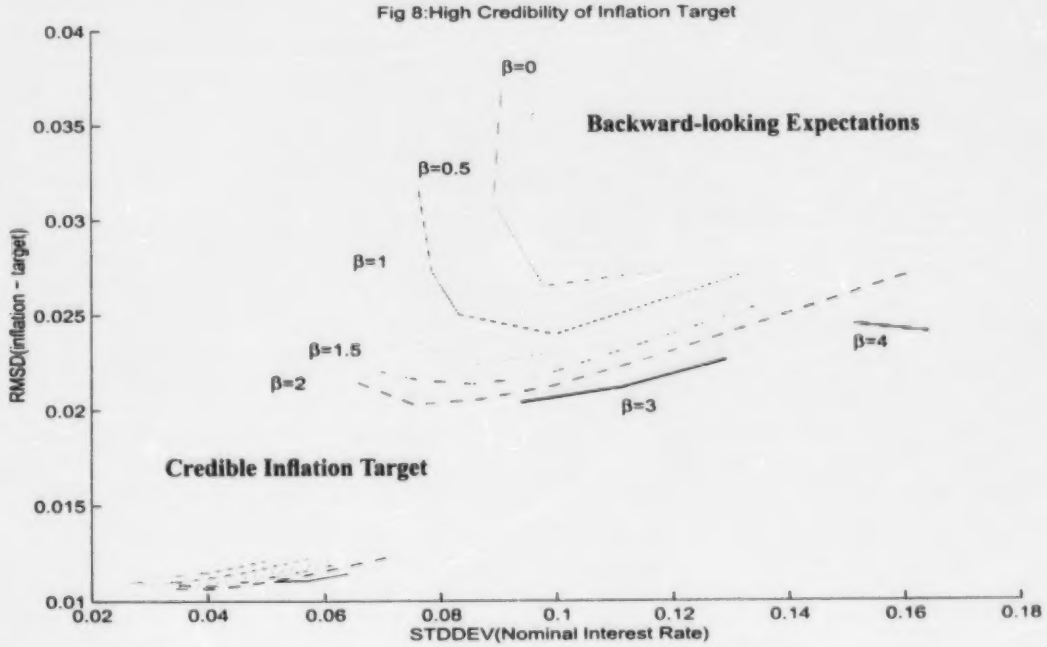

Fig 9:Price Level(solid) and Inflation(dashed) Expectations Close to Base Case QPM

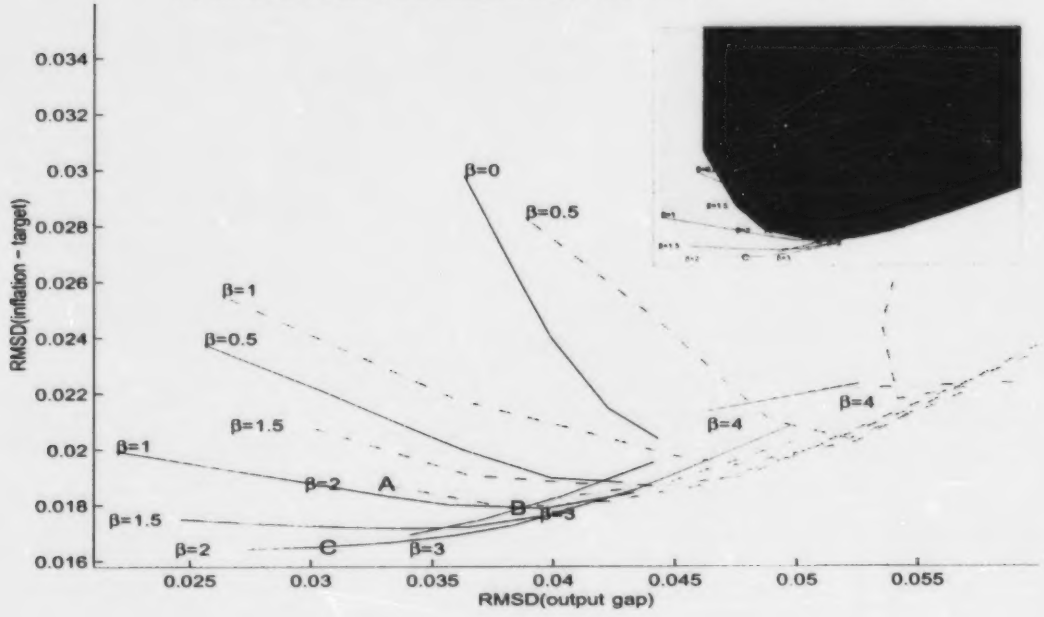

Fig 10:Price Level(solid) and Inflation(dashed) Targetting Expectations Close to Base Case QPM

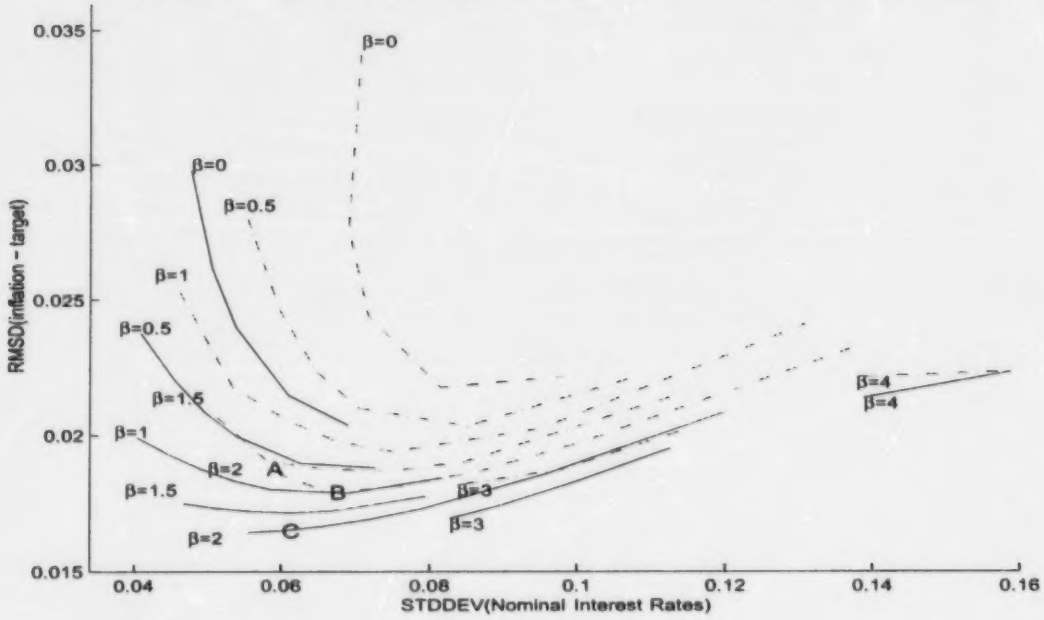

Fig 11:Price Level(solid) and Inflation(dashed) Expectations Close to Base Case QPM

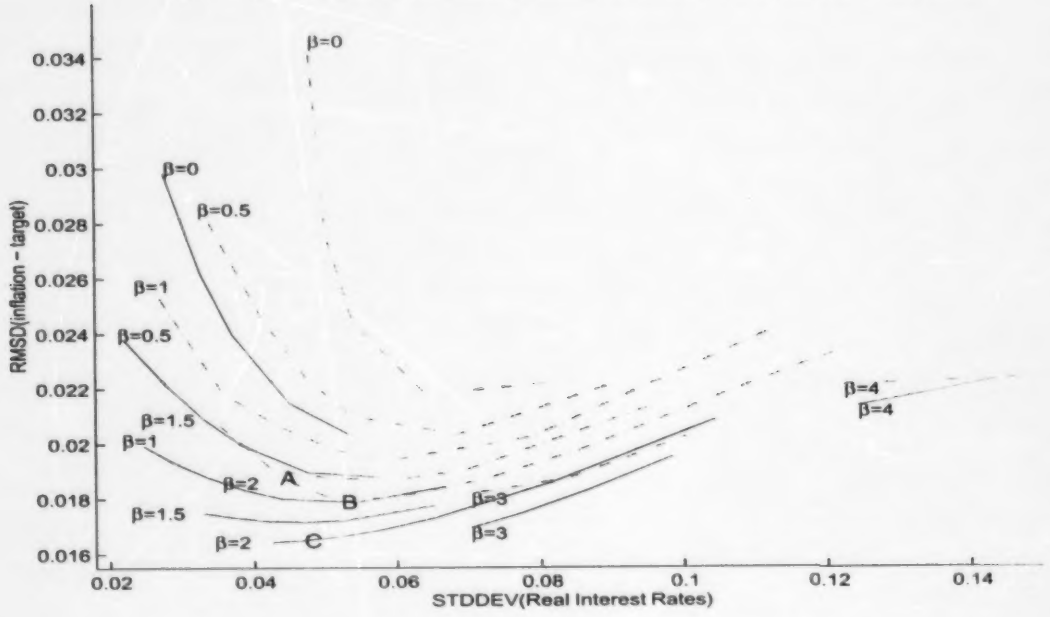

Fig 12: IFB Rules, BW expectations: Leads on the Price Level

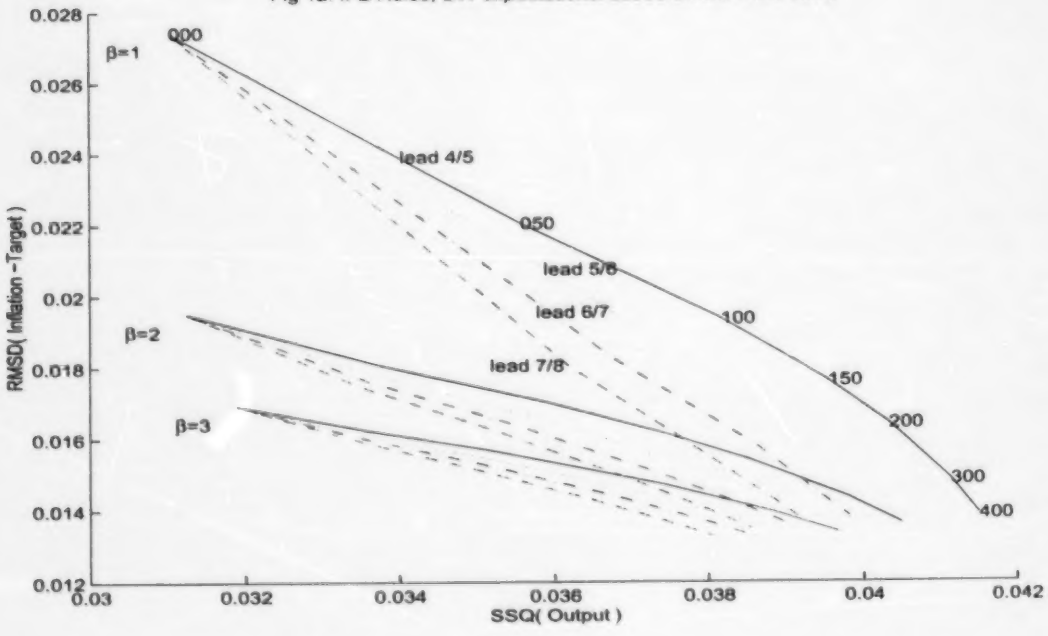

Fig 13: IFB Rules, BW expectations: Leads on the Price Level

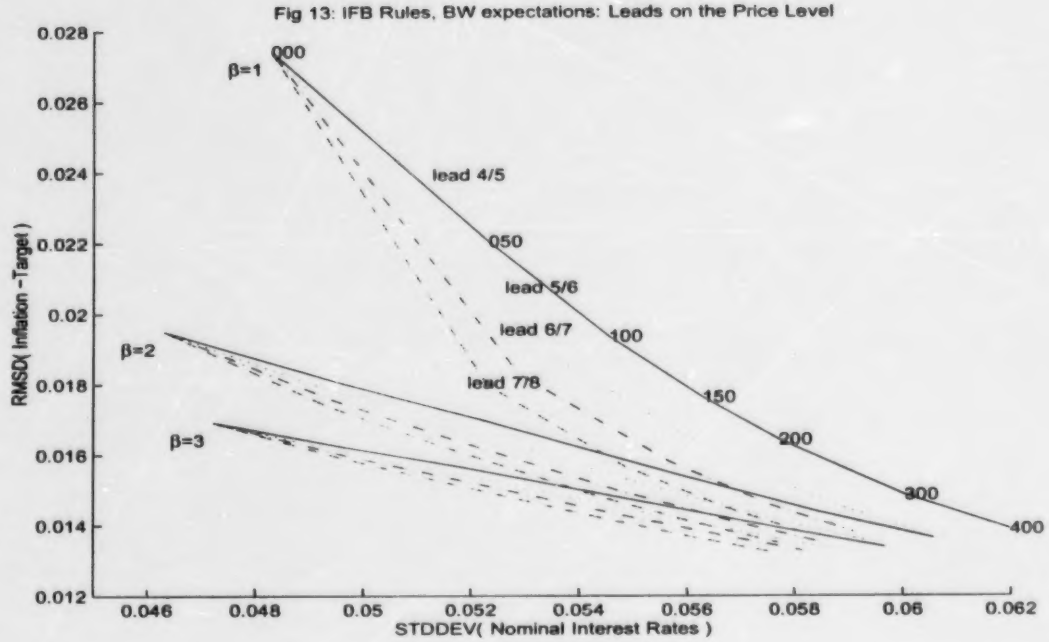

Fig 14: IFB Rules, MC expectations: Leads on the Price Level

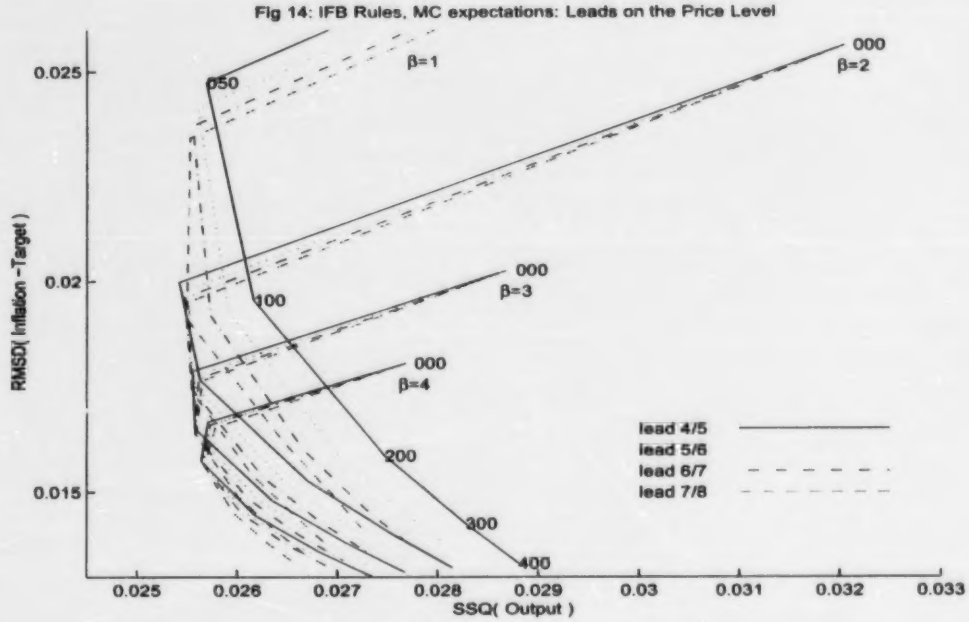

Fig 15: IFB Rules, MC expectations. Leads on the Price Level

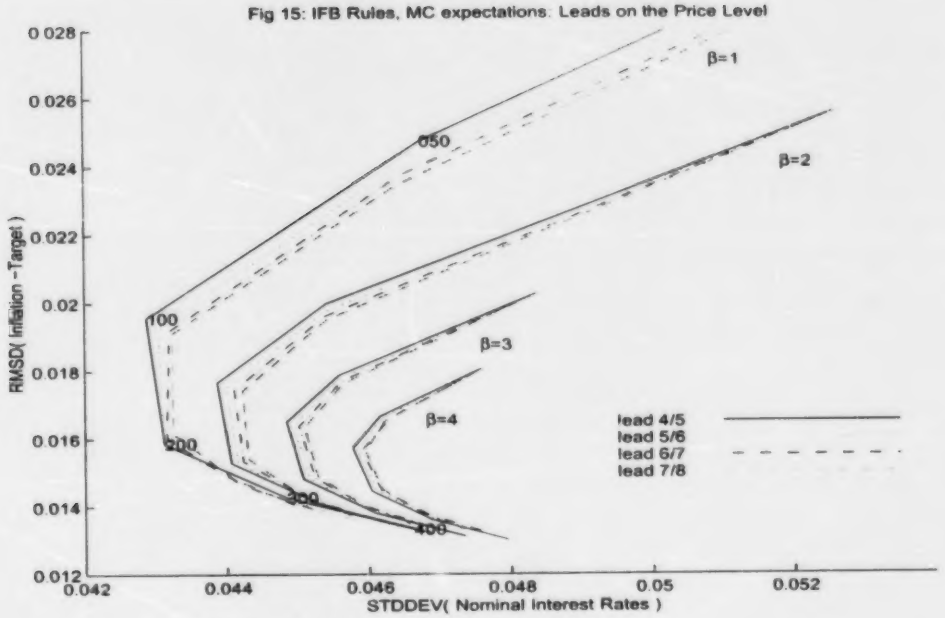

Fig 16: IFB Rules, MC expectations: Leads on the Price Level

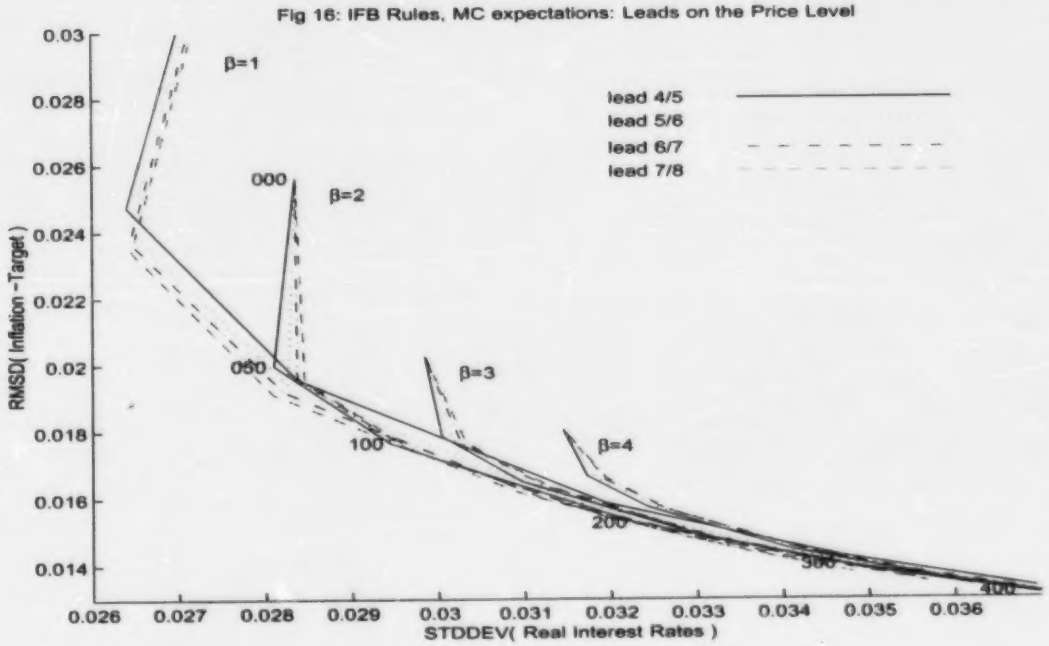

Fig 17: MC expectations using traditional Taylor rule, varying weight on output

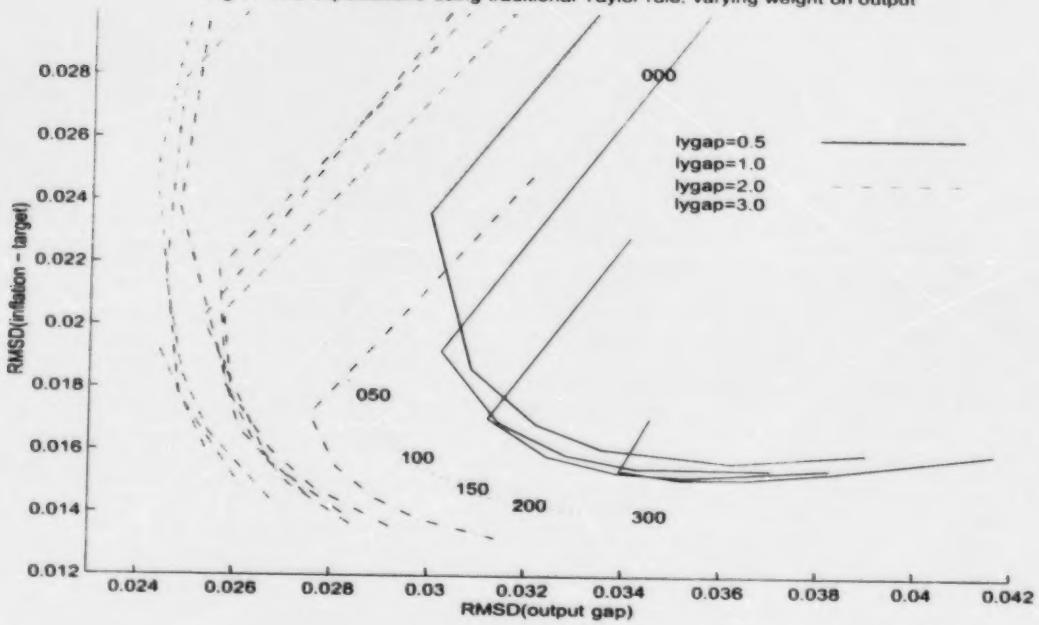

Fig 18: MC expectations using traditional Taylor rule, varying weight on output

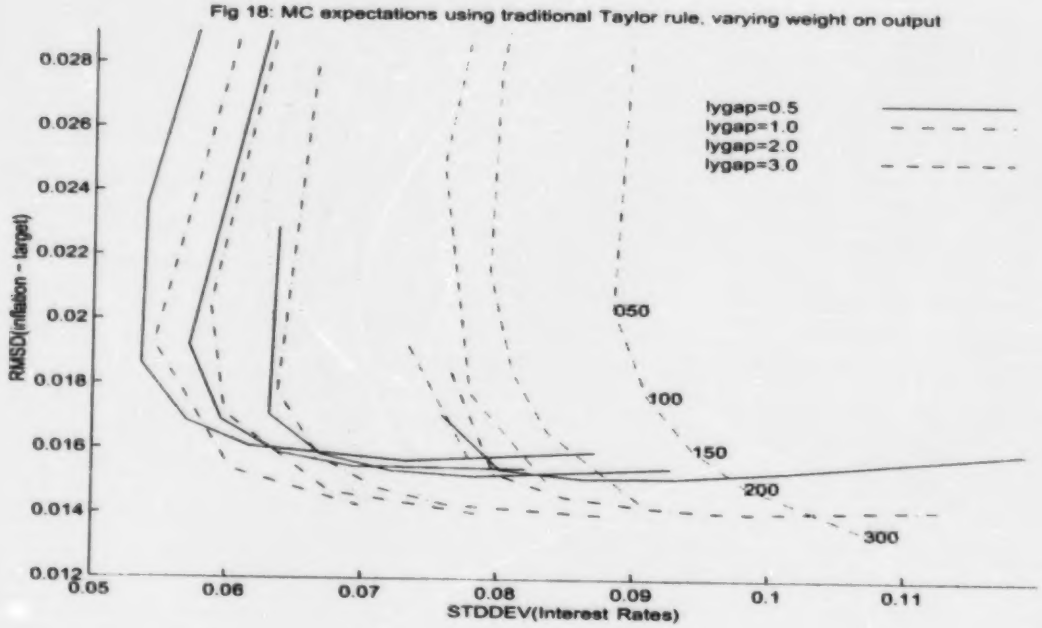

Fig 19: MC expectations using change rule, varying weight on output

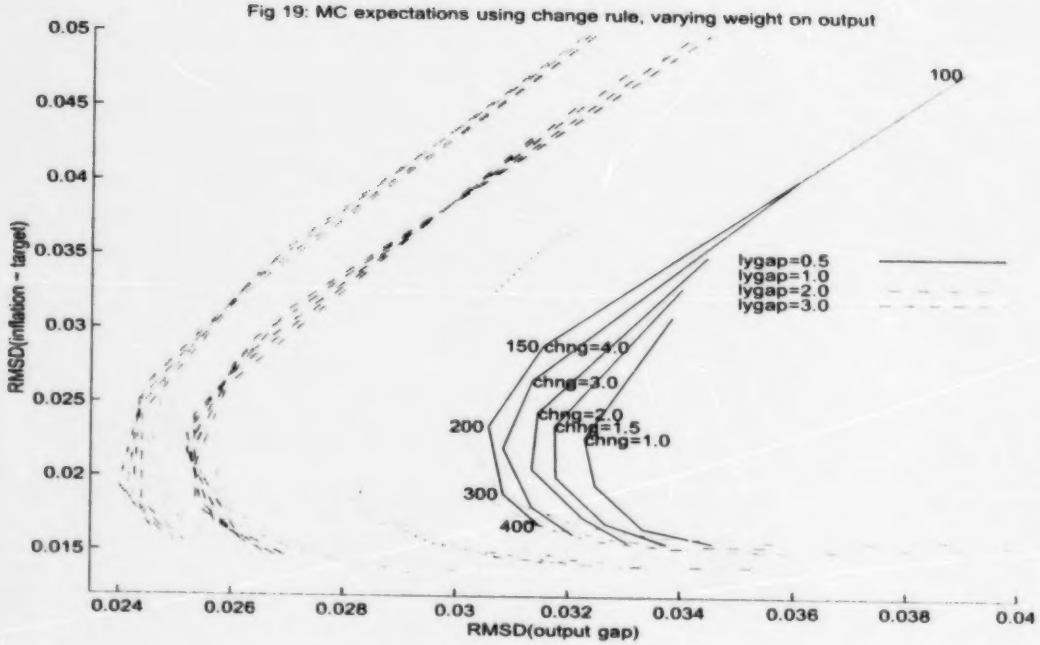

Fig 20: MC expectations using change rule, varying weight on output